RP 304 Rotor Lightning Protection Systems

The following recommended practice (RP) is subject to the disclaimer at the front of this manual. It is important that users read the disclaimer before considering adoption of any portion of this recommended practice.

This recommended practice was prepared by a committee of the AWEA Operations and Maintenance (O&M) Committee.

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Purpose and Scope

The scope of "Rotor Lightning Protection Systems" addresses proper maintenance and testing of wind turbine rotor/blades lightning protection equipment.

Introduction

This section contains recommendation in how to secure that a specific lightning protection system in a blade or in a complete rotor and hub system is maintained in a reasonable manner. The information in this section should give the reader an understanding of where to focus and what kind of documentation that gives the requested certainty in the provided system. The recommendations given in this section are based on general requirements given in the standard "*IEC 61400-24 Wind Turbine System - Part 24: Lightning Protection*" governing requirements for lightning protection of wind turbines and are based on the state-of-the art in the wind turbines industry.

Wind Turbine Rotor Lightning Protection Systems

1. Inspections

The standard IEC 61400-24 requires regular inspections during the lifetime process of the wind turbine to secure the following:

- The LP system conforms to its original design and functionality
- All parts of the LP system are in good conditions and still capable of protecting the wind turbine with required performance until next scheduled maintenance

1.1. Inspection Intervals/Events

The inspections should, at a minimum, be performed on the following occasions:

- During production
- On-site before installation
- During installation
- After final commissioning of the wind turbine
- Scheduled inspections
  - Annual visual inspection
  - Bi-annual full inspection
- After extensive repair situations
- After severe lightning strikes

1.2. Pre-Purchase Audit

During the pre-purchase phase the buyer, or an inspector representing the buyer, must get a general understanding about the lightning protection philosophy covering the rotor and hub.

The producer must present how the overall lightning protection system is expected to work and how the lightning protection concept has been verified.

Detailed design documentation should be provided. This design must secure high efficiency in lightning interception and the rotor must be capable of withstanding the physical effects of lightning without catastrophic failures.

The blade lightning protection system should comprise an adequate tip section protection including protection of internal conductive and semi-conductive parts. Test reports and other kinds of verification must be presented to document the desired protection performance. The down conductor system must be able to handle impulse current of at least 200kA at 10/350 µs (lightning protection level 1 in accordance with IEC 61400-24) without signs of internal arcing and without temperatures exceeding critical levels in relation to conductor isolation and GFRP/CFRP materials in general. In case of semi-conductive materials, such as carbon fibers, or other conductive elements such as sensors, heating elements, actuators etc., installed in the blade, it must be ensured that the presence of these systems and components are not compromising the safety and functionality of the blade.

Arc Entry tests must document the design lifetime of the air termination points (receptors).

1.2. Pre-Purchase Audit
(continued)

In blades with a lightning current transfer system located in the root section to protect the pitch bearings and drive train against lightning current penetration, these transfer systems must be designed in a robust way to secure mechanical stability and good lightning current carrying capability. It must be documented that the designed solutions have the desired function and lifetime performance.

In or around the hub section the lightning current path must be defined and secured such that no mechanical, hydraulic, or electrical components are exposed to direct or indirect lightning effect exceeding the withstand level of the component.

The inspector should audit the production facility to verify that the actual system is produced in accordance with the provided design. Lightning Protection Systems can be very different and the inspection points may be different from one system to another. It is important to define the inspection points as soon as the lightning protection concept is known.

For all blade lightning protection systems it is important that connections between different conductors are performed correctly. It is important that the right tooling and instructions are available in production. In cases with bolted connections that are not visible for inspection during the blade lifetime, these connections must be locked in a way that secures a good connection during the entire lifetime.

All connections must be checked by measuring the resistance before the connection is covered by resin or the blade mold is closed. Resistance measurements must be performed with a calibrated ‘4-point measuring method’ instrument and all individual sub-connections must demonstrate resistances below 1 mΩ.

Finally, the entire lightning protection system must be checked by resistance measurement and the threshold value for the entire system must be defined by the natural resistance in the down conductor system added to the resistances in the connections in the system.

A good rule of thumb is to have 0.5 mΩ per meter blade length in total resistance. If this cannot be demonstrated the reasons must be sorted out and it must be decided by the inspector if the system can be accepted.

A diagram indicating the resistances in the system should be provided as a part of the blade documentation and all measurement data must be stored in the blade production file and made available for the inspector at any time.

1.3. During Production

During production, all conductors and connections must be inspected for correct installation. Resistance measurements must be taken regularly to ensure that all connections demonstrate low resistance values.

Attention should focus on electrically isolating materials (resin, sealing compound, etc.) used on electrical connections.

The lightning protection systems must be checked by measurement before the blade is closed or infused, depending on the production method. It is recommended that the resistances in the system are measured regularly during the production to make sure that no surprises occur.

Before the blade leaves production, the total resistance in the system must be measured and must still be within the tolerable range.

1.4. On Site Prior to Installation

Before the blade is installed on site, the total resistance in the system must be measured and must still be within the tolerable range. All connections must be inspected and the desired resistances in the system must be documented by measurement. Measurements are taken from the blade root termination point to all air termination points (receptors) in the system. (*See Figure A*) All measurements must be stored in the blade file.

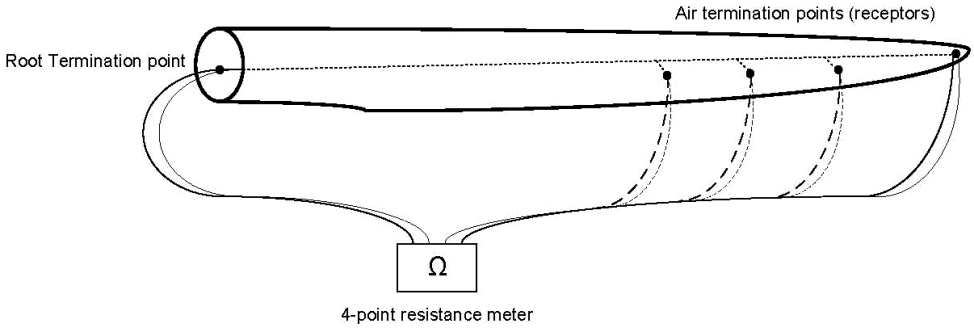

Figure A: 4-point Resistance Measurement From Root Termination Point to Air Termination Points (Receptors).

1.5. During Installation

SAFETY NOTE: Installation work cannot be carried out during thunderstorms. The risk of strikes to the turbine has to be considered by the site responsible person and no persons are allowed in the uncompleted turbine in the event of a lightning strike.

During installation of the rotor it is important to connect the lightning protection system to ground as early in the process as possible.

SAFETY NOTE: It has to be realized that even without thunderstorm activity, the blade can be static electric charged during the crane hoisting and installation and the installation crew should be instructed how to approach the floating blade and un-grounded lightning protection system.

It is recommended to consider a solution ground the blade without the installation crew touching the blade, eventually by use of an isolated ground stick.

When the turbine is erected and the blades are installed, there is a risk of lightning strikes before the turbine is finally commissioned and put into operation. The turbine must be secured such that the lightning protection system is completed as soon as possible in the erection process to avoid human injuries or system damages. It is important that the main lightning current path from the blade lightning protection system to the hub/nacelle/tower and further to the foundation grounding system is established.

Verify by visual inspection and resistance measurements that all intended lightning protection connections are fully functional immediately after erection. All inspection instructions and checklists must be stated in the relevant erection manuals. Resistance measurement values must be noted in the turbine file.

During power and control cable installations in the hub, nacelle, and tower, consider how cables are grounded in case of an approaching thunderstorms. Cables that are left unconnected and ungrounded can introduce a significant risk of flash-overs and damages to cables and equipment. Electrostatic discharges may occur and personnel may be injured.

1.6. After Final Commissioning of the Wind Turbine

After the turbine has been commissioned the lightning protection system must be checked before the turbine is put into operation. All connections must be inspected and the desired resistances in the system must be documented by measurement. Measurements are taken from the blade root termination point.

1.7. Scheduled Inspections

According to IEC 61400-24, the lightning protection system must be inspected every year of operation. Every year the lightning protection system must be inspected visually, and every second year the inspection should be extended to cover a full inspection, including continuity measurements and an in-depth inspection.

1.8. Yearly Visual Inspection

During the yearly visual inspection, the following points should be inspected:

- Root termination point: no broken/loosened parts
- Connection to pitch bearing, if relevant
- Cable connection: no broken/loosened parts
- Lightning Current Transfer System, if installed
    - Mechanical parts: no broken/loosened parts
    - Electrical parts, cables, brushes, etc.: no broken/ loosened/worn parts
- Lightning registration card changed, if installed

1.9. Bi-annual Full Inspection

During the yearly visual inspection the following points should be inspected:

- Root termination point: no broken/loosened parts
- Connection to pitch bearing, if relevant
- Cable connection: no broken/loosened parts
- Lightning current transfer system, if installed
    - Mechanical parts: no broken/loosened parts
    - Electrical parts, cables, brushes, etc.: no broken/ loosened/worn parts
- Lightning registration card changed, if installed

1.9. Bi-annual Full Inspection
(continued)

- Measurement of resistance in the following connections:
  - Root termination point to all air termination points (receptors)
  - Connection from root termination point to nacelle
  - External grounding systems to neutral, distant ground

1.10. After Extensive Repair Situations

After events with extensive repairs where the blade has been taken down, the lightning protection systems must be inspected again. The same procedure as described in Steps 9.2.2, 9.2.3, and 9.2.4 must be followed before, during, and after the blade re-installation.

1.11. After Severe Lightning Strikes

In the event of a severe lightning strike, an inspection of the entire lightning protection system must be considered. If there are no defects observed, the turbine operation should be continued. However, it can be expected that delayed failures will show up in the weeks/months after the strike.

If the lightning strike causes damage that requires a repair to the blade laminate, lightning protection system, the lightning current transfer system, etc., the repair must be followed with a resistance measurement to ensure that a tolerable resistance is maintained after the repair.

It is important to ensure that the conductors and connections inside the blade are repaired in the right way for proper function.

In cases with regular damage caused by lightning strikes, improvements to the lightning protection efficiency should be considered as a goal in the repair.

In severe cases, improvements should be installed proactively, but only improvements that are proven and verified to have a higher performance should be installed.

2. Maintenance

3. Repair

All repairs where under warranty or past the warranty period should be conducted with OEM approved materials. The primary goal of all repairs is to return the lightning system to the same performance characteristics as when it was commissioned.

4. Additional suggestions

Request references verifying previous experience in performing the type of necessary repairs from potential vendors

Investigate variances between the intended repair processes and those recommended by the component supplier or the OEM.

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Chapter 4 Towers

Operations and Maintenance
Recommended Practices

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